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Presented for filing is a new original patent application of:

Applicant: MARK SANDERS

Title: CONTENT PROPAGATION IN INTERACTIVE TELEVISION

Enclosed are the following papers, including those required to receive a filing date under 37 CFR 1.53(b):

	<u>Pages</u>
Specification	30
Claims	11
Abstract	1
Declaration	1
Drawing(s)	14

Enclosures:

— Postcard.

Executed Assignment along with a check for \$40 for the filing fee.

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This application is entitled to small entity status. A Verified Statement (Declaration) Claiming Small Entity Status will be filed at a later date.

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APPLICATION  
FOR  
UNITED STATES LETTERS PATENT

TITLE: CONTENT PROPAGATION IN INTERACTIVE  
TELEVISION

APPLICANT: MARK SANDERS

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**CONTENT PROPAGATION IN INTERACTIVE TELEVISION**

**TECHNICAL FIELD**

This invention relates to interactive television.

**BACKGROUND**

5 Interactive television systems provide viewers with network access to video servers that offer a large plurality of viewing selections. To make a viewing selection, a viewer looks at a menu transmitted by the system and selects a viewing asset. The viewer issues a request for the selected  
10 asset through a network that connects his or her television to the interactive television system. In response to receiving the viewer's request, the interactive television system uses the network to stream the requested asset from one of the video servers to the viewer's television. The collection of  
15 video data objects and related data objects such as posters, descriptions, and preview objects, may together form a complete viewing asset.

In an interactive television system, the selection of available viewing assets is preferably large. Furthermore,  
20 the viewing assets themselves often include large video data objects. The desire to offer large selections to viewers means that such systems need very substantial data storage resources for viewing assets.

An interactive television system may store a large amount  
25 of asset data on an array of servers. Typically, only a subset of the servers is accessible to a single viewer, because one server cannot server every viewer. In such a system, an individual asset may have to reside on several servers so that different viewers can access the asset.

The collection of accessible assets may also change over time. Changes to the collection of assets may respond to asset popularity shifts and/or viewing population changes.

#### SUMMARY

5 In one aspect, the invention features a process of propagating viewing assets on a system of video storages. The process includes copying a missing portion of a replica of a selected viewing asset onto a target video server. The act of copying is responsive to determining that a priority to  
10 propagate the selected asset to the target server is higher than a retention value of a replica of one or more viewing assets stored on the target server.

In some embodiments, the act of copying includes writing the missing portion of the replica of the selected asset onto  
15 a storage region of the target video server that previously stored a portion of the replica of one or more viewing assets. The copying may include reading the missing portion from video servers that serve viewers.

In some embodiments, the act of selecting a portion of  
20 the replica of one or more viewing assets is responsive to the replica of one or more viewing assets having a data size at least as large as a data size of the missing portion of the selected asset.

In some embodiments, the process also includes assigning  
25 priorities to propagate to a plurality of viewing assets, ranking the viewing assets according to the assigned priorities, and choosing the selected asset for copying in response to the selected asset being ranked above a preselected minimum rank.

30 In a second aspect, the invention features a process for propagating digital viewing assets to video servers. The

process includes assigning to each of a plurality of digital viewing assets a priority to propagate the asset onto video servers, ranking the assets based on the assigned priorities; and propagating one of the assets to one or more selected video servers. The act of propagating is responsive to the one of the assets having a preselected minimum ranking.

In some embodiments, the act of assigning includes assigning a viewing asset to a usage class. The usage class provides a contribution to initial values of the priorities to propagate assets assigned to the class.

In some embodiments, the process further includes accumulating usage data on individual assets stored on the video servers and updating the priorities to propagate based on the usage data. The usage data may include numbers of viewer requests during predetermined time periods and differences between numbers of viewer requests during earlier and later predetermined periods.

In a third aspect, the invention features a process for propagating viewing assets onto a video storage. The process includes assigning propagation priorities to viewing assets, constructing a table of element deletion lists for a target video storage, and selecting a group of element deletion lists from the table. The group has a data size at least as large as a data size of a portion of a replica of another asset not stored on the target storage. The process also includes copying the portion of a replica of the other asset onto the target video storage in response to the propagation priority of the other asset being larger than a retention value of the group.

In some embodiments, the act of copying includes writing the portion onto a region of the target video storage previously storing the group.

In some embodiments, the act of selecting a group includes constructing a table listing sets of element deletion lists with lower retention value than the priority of the other asset. The act of selecting includes picking one of the lists having a data size at least as large as the portion of the replica of the other asset.

In a fourth aspect, the invention features a process of distributing viewing assets to viewers. The process includes assigning priorities to assets, selecting a video server, and copying one of the assets onto the video server. The priorities are priorities for distributing the associated assets to video servers accessible to viewers. The act of copying is responsive to determining that the priority associated with the one of the assets is greater than a retention value associated with a set of viewing assets having replicas on the video server. The replicas occupy enough space to store the one of the assets.

In some embodiments, the copying includes searching for one or more sets of replicas of asset elements to delete on a table of element deletion lists.

In some embodiments, the process further includes accumulating data on usage of individual ones of the assets. Then, the act of updating is based at least in part on the accumulated data.

In a fifth aspect, the invention features an interactive television system. The system includes a network or bus, a plurality of video servers to store digital replicas of viewing assets for viewers, and a control unit connected to the video servers. The video servers are connected by the network or bus. The control unit orders copying of a missing portion of a replica of a selected asset to one of the video servers if a priority to propagate the selected asset onto the

one of servers is higher than a value of retaining a replica of one or more other assets already stored on the target server.

In some embodiments, the system also includes a plurality of distribution networks to provide channels for delivering viewing assets to viewer televisions. Each distribution network connects to portion of the video servers.

In a sixth aspect, the invention features a process for propagating digital viewing assets onto video servers. The process includes propagating a plurality of viewing assets onto video servers based on priorities to propagate, accumulating usage data on individual assets stored on the video servers, and updating the priorities based on the usage data. The priorities provide a ranking of the assets.

In some embodiments, the process includes assigning a viewing asset to a usage class that provides a portion of an initial value for the priorities to propagate the assets assigned to the class. The process may also include calculating the priority to propagate a selected one of the assets onto one of the video servers. The calculation may be based on a global priority to propagate the selected one of the assets and a local priority to propagate a replica of the selected one of the assets onto the one of the video servers. The global priority may be based in part on a counter value that measures usage of the selected one of the assets. The local priority may be based in part on a bandwidth for streaming the selected one of assets from the one of the video servers to a set of viewers.

In various aspects, the invention features a data storage media storing a computer executable program of instructions for performing one or more of the above-mentioned processes.



Other features, objects, and advantages of the invention will be apparent from the description and drawings, and from the claims.

### DESCRIPTION OF DRAWINGS

5        FIG. 1 is a block diagram of an interactive television system;

      FIG. 2 illustrates asset delivery pathways of the media clusters shown in FIG. 1;

10       FIG. 3 is a high-level block diagram of software processes that manage and control the interactive television system of FIG. 1;

      FIG. 4 illustrates interactions between a propagation service process and other processes of FIG. 3;

15       FIG. 5A is a flow chart for a process that ranks viewing assets and evaluates retention values of replicas of asset elements and entries in element deletion lists;

      FIG. 5B is a flow chart for a process that decides whether to propagate a replica of an asset to a media cluster;

20       FIG. 6 is a flow chart illustrating a process that calculates total propagation priorities of replicas of assets;

      FIG. 7 is a flow chart illustrating a process that determines whether to copy a replica of a viewing asset onto a media cluster;

25       FIG. 8A illustrates relations between replicas of viewing assets and replicas of asset elements stored on a media cluster;

      FIG. 8B illustrates ELists for the replicas of viewing assets and asset elements shown in FIG. 8A;

30       FIG. 8C illustrates replicas of assets, replicas of asset elements, and ELists that remain on the media cluster of FIG. 8A after deletion of the asset elements of one EList;

FIG. 8D is a table enumerating the ELists remaining in FIG. 8C;

FIG. 9A is a table showing the ELists shown in FIG. 8B;

FIG. 9B is a table that enumerates "combinations of ELists" from FIG. 9A with retention values below 50;

FIG. 10 is a flow chart illustrating a process that uses ELists to free space for propagating replicas of new assets; and

FIG. 11 is a flow chart illustrating a process that initially defines and subsequently updates a new asset's global propagation priority;

Like reference symbols in the drawings indicate like elements.

## DETAILED DESCRIPTION

### Interactive Television System

FIG. 1 shows a networked system 10 that provides interactive television to subscribing viewers. The system 10 includes a set of control units 16. The control units 16 connect to each other through a multi-channel communications bus 12. In some embodiments, the bus 12 may be a network. The bus 12 also couples a plurality of media clusters 40, 40', 40'', which store replicas of viewing assets for viewers. The media clusters 40, 40', 40'' couple to node groups of local viewers 20, 20', 20'', 20''' through hybrid fiber coaxial (HFC) networks 22, which function as broadband or multi-channel broadcast networks for the local node groups 20, 20', 20'', 20'''. The HFC networks 22 carry viewing assets from the media clusters 40, 40', 40'' to interactive viewer televisions 24 and carry viewing status data and viewing requests from the televisions 24 up to the media clusters 40, 40', 40'' and control units 16.

The arrangement of control units 16 and media clusters 40, 40', 40" may serve a large number of viewers. For example, each media cluster 40, 40', 40" may serve between about ten to fifty thousand local viewers. The connectivity between individual media clusters 40, 40', 40" and individual node groups 20, 20', 20", 20''' may differ from cluster to cluster. For example, the media cluster 40 couples to node groups 20 and 20' while the media cluster 40" couples to node groups 20" and 20'''. Thus, different viewers may be served by different subsets of the media clusters 40, 40', 40".

Each interactive viewer television 24 includes a set top box 26 that connects a normal television 25 to the local HFC network 22 and provides an interface for communicating with a portion of the media clusters 40, 40', 40" and control units 16. The set top boxes 26 receive viewing assets from the associated HFC networks 22, decode the received assets, and display the decoded assets on a normal television 25. In some embodiments, the set top boxes 26 may be integrated into the televisions 25. The set top boxes 26 also receive menus of available viewing assets, display the menus on the normal televisions 25, and transmit viewer requests for viewing assets and streaming-control commands to the control units 16. The streaming-control commands implemented by the set top boxes 26 may include stop, pause, fast-forward, and reverse.

The viewing assets are sequences of encoded digital files for video, text, audio, graphic, and/or interactive control applications. Each file of the sequence, for a viewing asset, will be referred to as an asset element. The displayed viewing assets may, for example, be movies, newscasts, shopping emissions or interfaces, posters, or audio presentations.

Each control unit 16 includes a computer 28, a data storage media 30, e.g., a hard drive or compact disk, for storing software processes executable by the computer. The control units 16 manage viewing assets on the media clusters 40, 40', 40" and control delivery of these assets to viewers. The management of assets includes propagating assets among the media clusters 40, 40', 40" and accumulating asset usage data to insure that the propagation of assets to the media clusters 40, 40', 40" anticipates viewer demand. The controlling asset delivery includes receiving, viewing requests from individual interactive televisions 24 and assigning asset delivery pathways from the media clusters 40 to the node groups 20, 20', 20", 20''' corresponding to requesting viewers.

Each media cluster 40, 40', 40" stores replicas of viewing assets that are currently available to the node groups 20, 20', 20", 20''' connected to the media cluster 40, 40', 40". The selection of viewing assets varies from media cluster to media cluster 40, 40', 40". The media clusters 40, 40', 40" stream viewing assets to associated local node groups 20, 20', 20", 20''' in response to control commands received from the control units 16. The control units 16 send such control commands in response to receiving requests for viewing assets from the various node groups 20, 20', 20", 20'''.

Each media cluster 40, 40', 40" has space for storing a limited number of replicas of viewing assets. The media clusters 40, 40', 40" store assets for meeting present and near-future viewing demands. To handle changing viewing demands, the control units 16 regularly update the asset selection on the media clusters 40, 40', 40" by copying replicas of new viewing assets to the media clusters 40, 40', 40" and/or by copying viewing assets between different media clusters 40", 40, 40'. To propagate an asset, a control unit

16 first copies a replica of a new asset to a preselected one of the media clusters 40, 40', 40" and then orders cluster-to-cluster copying to propagate the asset to other clusters 40, 40', 40". The control units 16 update the viewing asset selection on the media clusters 40, 40' 40" to maximize the economic value that the entire asset collect provides to the system 10 as is explained below.

Though the system 10 of FIG. 1 is not hierarchical, other embodiments may use hierarchical organizations of media clusters and/or control units, e.g., in master-slave relationships. In those embodiments, master servers control slave servers and provide for larger video storages. Several hierarchical organizations of media clusters or video servers are described in U.S. Patent No. 5,862,312 and U.S. Patent Application No. 09/293,011, filed April 16, 1999, which are both incorporated by reference herein.

FIG. 2 shows media clusters 40, 40', 40" in more detail. Each media cluster 40, 40', 40" has several video data servers 42, 42', 42" that locally interconnect through a network or bus 34, 34', 34". The servers 42, 42', 42" of the same cluster 40, 40', 40" share a data storage 36, 36', 36", which may be physically lumped or spread over the individual local servers 42, 42', 42". The servers 42, 42', 42" delivery viewing assets from the cluster video storages 36, 36', 36" to node groups 20, 20', 20", 20''' connected to the associated media cluster 40, 40', 40". The video data storages 36, 36', 36" store replicas of the viewing assets, which the media cluster 40, 40' can deliver to local node groups 20, 20', 20", 20'''. The selection of replicas of assets stored on different clusters 40, 40', 40" may differ so that different media clusters 40, 40', 40" do not generally provide identical

viewing selections to the locally connected node groups 20, 20', 20", 20'''.

FIG. 2 also shows some of the delivery pathways between various media clusters 40, 40', 40" and local node groups 20, 20', 20", 20'''. Each delivery pathway includes one of the servers 42, 42', 42", an output card of the server, a quadrature amplitude modulator (QAMs) 50, a combiner 52, 52', 52", 52''' and an HFC 22 that connects the destination node group 20, 20', 20", 20'''. The servers 42, 42', 42" have one or more output cards, which produce streams of digital data packets for transporting viewing assets to the node groups 20, 20', 20", 20'''. The output streams are received by QAMs 50 that connect to the output cards. Each QAM 50 reads headers of received packets and retransmits the packets towards the node group 20, 20', 20", 20''' served by the QAM 50 if that node group 20, 20', 20", 20''' is a destination of the packet. The retransmitted packets are received by combiners 52, 52', 52", 52'', which send broadband transmissions from several QAMs 50 to the associated node groups 20, 20', 20", 20''' via the associated HFC 22.

Referring again to FIG. 1, the different media clusters 40, 40', 40" may have different delivery pathways to the node groups 20, 20', 20", 20'''. The control of delivery of viewing content over these delivery pathways and the management of replicas of assets stored on the media clusters 40, 40', 40" are both performed by the control units 16. The control units 16 execute processes that perform these functions and are able to manage in excess of ten thousand assets and a variety of control application types. An individual control unit 16 may perform the above-functions for some or all of the media clusters 40, 40', 40".

## **Processes Controlling Assets**

Assets are the smallest viewable objects that can be requested by or streamed to viewers. Replicas of assets can be activated or deactivated on the media clusters 40, 40', 40". An asset may include several elements, e.g., consecutive portions of a movie, a movie poster, and a movie trailer. The elements of an asset are individual files and are the smallest data objects that can be copied to or deleted from a media cluster 40, 40', 40". Physical copies of assets and asset elements on particular media cluster 40, 40', 40" are referred to as replicas of assets and replicas of asset elements, respectively.

FIG. 3 is a block diagram showing software processes executed by the computers 28 of the control units 16 to manage and control viewing assets and asset usage in the interactive television system 10 shown in FIG. 1. On each control unit 16, the processes include modules 62, 64, 66, 68, 70, 72, 74, 76, which perform asset management, directory service, propagation services, connection management, streaming services, movies-on-demand (MOD) control application services, MOD billing services, and program guide services. In some embodiments, other processes may provide control application services and billing services for content types, such as news-on-demand (NOD), interactive shopping, and interactive games (not shown). On each media clusters 40, 40', 40", resident processes include an instance of a media cluster agent 78. On the set top boxes 26, resident processes include one or more application agents 80, e.g., a MOD application agent.

FIG. 4 illustrates functional relationships between the software process modules 62, 64, 66, 68, 70, 78 that manage and control assets. These relationships are further described below.

The asset management module 62 provides an interface for receiving new viewing assets into the control unit 16. The interface may, e.g., support automated downloads of viewing assets from a distribution cable (not shown) and/or manual uploads of viewing assets under control of a user operating a graphical user interface. For each newly received asset, the asset management module 62 creates an automated work queue 63 that controls the life cycle of the associated asset. The work queues 63 control the life cycle transitions performed by the propagation service (PS) module 66. An asset's life cycle may include states such as received; encoded; stored on some media clusters 40, 40', 40"; activated; deactivated; and deleted.

The asset management module 62 accepts several types of data objects including encoded data files, e.g., encoded according to the Movie Picture Experts Group (MPEG) standards, non-encoded data files, executable applications, and metadata associated with other assets. The received data assets may be for video, audio, text, graphics, or interactive applications.

The directory service module 64 provides assets with filenames arranged in hierarchical namespaces. The directory service module 64 keeps information about the element composition of assets and metadata associated with assets.

In various embodiments, the control applications may include movies on demand (MOD), television on demand (TVOD), news on demand (NOV), interactive shopping and others.

The propagation service module 66 controls copying of assets to and deleting of assets from individual media clusters 40, 40', 40". A media cluster 40, 40', 40" needs a replica of each element of an asset to be able to play the asset to viewers. But, replicas of different assets may share



replicas of some asset elements stored on the same media cluster 40, 40', 40".

5 The propagation service module 66 orders copying of new assets to a preselected one of the media clusters, e.g., cluster 40. The propagation service module 66 also orders copying of the asset replica to other ones of the media clusters, e.g., clusters 40', 40", to meet anticipated user demand for the assets, e.g., demands that are upcoming in the next few hours. The propagation service module 66 also  
10 provides location information on active replicas of assets to the other process modules 64, 68, 70.

15 The connection manager module 68 selects pathways for streaming viewing assets from media clusters 40, 40', 40" storing replicas of the viewing assets to viewers requesting the viewing assets. To optimize streaming, the connection manager module 68 uses an abstract representation of each potential delivery pathway. The representations indicate throughputs and bottlenecks along each pathway. The connection manager module 68 selects pathways with the highest  
20 available throughputs, i.e. the least restrictive bottlenecks, as the pathways for delivering assets to requesting viewers.

25 The connection manager module 68 also provides the abstract representation of delivery pathways for the propagation service module 66. This representation indicates available total bandwidths for delivering various viewing assets to local node groups 20. The propagation server module 66 uses this representation to determine when the available bandwidth for delivering an asset to viewers is so diminished that an additional replica of the asset is needed on another  
30 media cluster 40, 40', 40". The connection manager module 68 provides the representations of delivery pathways between

media clusters 40, 40', 40" and node groups 20, 20', 20", 20''' to other ones of the software modules.

The connection manager module 68 is also an interface that receives requests for assets from viewer televisions 24 and set top boxes 26.

The streaming service module 70 provides application-independent streaming services to the connection management module 68, control application service modules 72, and media cluster agents 78. The provided services include stream creation, operation, and tear down of delivery pathways. The streaming service module 70 also has interfaces for controlling media cluster agents 78 that reside on the individual media clusters 40, 40', 40".

The media cluster agents 78 copy new replicas of asset elements to and delete old replicas of asset elements from the associated media clusters 40, 40', 40" in response to commands or orders from the propagation service module 66.

The MOD application service module 72 resides on the control unit 16 and controls processing of viewer requests to purchase movies and other on-demand video assets. The MOD application server module 72 interacts with an application database 82 and the MOD billing service module 74 to check viewer credit status and to bill virtual video rentals. The MOD application service module 72 can suspend or resume asset streaming to viewers, monitors viewing progress, and records viewer activities in the database 82.

The MOD application client 80 resides on each set top box 26 and provides a viewer with system navigation interface for requesting a programming guide and requesting assets for viewing. The interface transmits a viewer's requests to one of the control units 16.

The program guide service module 76 provides program guide files to set top boxes 26, which in turn displays a program guide on the attached normal television 25. Viewers can request assets in the program guide for viewing.

For each media cluster 40, 40', 40" serviced, the propagation service module 66 generates and regularly updates a table of element deletion lists (ELists). In the table, each EList is identified by a "selected element" belonging to the EList. Each EList indicates a set of replicas of elements that can also be deleted if the identified selected element is deleted without incurring addition loss of retention value (RV) from the media cluster 40, 40', 40" storing the replicas.

#### **Management of Replicas of Assets on Media Clusters**

The propagation service module 66 controls propagations of viewing assets to and among the media clusters 40, 40', 40". The propagation service module 66 propagates assets to increase the economic value of the entire collection of assets available to viewers. The economic value of propagating a particular asset to a particular media cluster 40, 40', 40" is rated by a total propagation priority (TPP). TPPs enable comparisons of the economic values of potential propagations of assets to particular media clusters 40, 40', 40" of the interactive television system 10.

The asset propagation process includes a process 100 that ranks potential propagations and a process 110 that selects which asset propagations to perform.

Referring to FIG. 5A, a flow chart for the ranking process 100 is shown. The process 100 evaluates the TPP of potential asset propagations (step 102). A potential asset propagation identifies an asset and a target media cluster 40, 40', 40" to which the identified asset can be propagated. The

target cluster 40, 40', 40" does not already store a replica of the asset. Using the TPPs, the process 100 ranks the set of potential asset propagation in a list (step 104).

Potential asset propagations with higher TPPs are ranked

5 higher and correspond to propagations predicted to provide larger increases the economic value of the entire collection of replicas of assets stored on media clusters 40, 40', 40".

The ranking process 100 also assigns a retention value (RV) to each replica of an asset (step 106). The assigned RVs

10 depend both on the asset and on the media cluster 40, 40', 40". The retention value, RV, indicates the value to the entire system 10 of keeping the associated replica of the asset on the associated media cluster 40, 40', 40". From the RVs of replicas of assets, the process 100 calculates the RVs  
15 of element deletion lists (step 108). Element deletion lists, which are described below, are groups of replicas of asset elements that can be deleted together. The ranking process 100 is repeated at regular intervals.

Referring to FIG. 5B, a flow chart for a propagation  
20 selection process 110 is shown. The process 110 selects the highest ranked potential asset propagation that remains on the ranking list (step 112). The selected potential propagation has the largest TPP among potential asset propagations, which have not already been processed. The process determines

25 whether the associated target media cluster 40, 40', 40" of the selected potential asset propagation has a suitable storage region for a replica the asset (step 114). A suitable storage area is storage space that is large enough to store a replica of any elements of the asset not already on the target  
30 media cluster 40, 40', 40", i.e., any missing elements, and that has a total RV that is smaller than the TPP of the selected asset. If a suitable storage area exists, the

process 110 selects the most appropriate region; orders copying of replicas of the missing elements of the selected asset from another media cluster 40, 40', 40" onto the most appropriate region; and then updates RVs, ELists, and combinations of ELists of the target cluster 40, 40', 40" (step 116). The most appropriate region has the smallest total RV value and among such regions the smallest size. The copying replaces existing replicas of the most appropriate region with missing replicas of the asset being propagated. After considering the selected propagation, the process 110 loops back 118 to select the remaining asset propagation on the ranking list having the next highest TPP.

FIG. 6 is a flow chart for a process 120 that calculates TPPs of potential asset propagations. The propagation service module 66 determines a global propagation priority (GPP) for a viewing asset, which is available for copying onto the media clusters 40, 40', 40" (step 122). The GPP is a time-dependent number, e.g., in the range of 0 to 100, that expresses the economic value of making a new replica of the associated asset available to viewers. The process 120 also determines a local propagation priority (LPP) for copying a replica of the asset onto a particular target media cluster 40, 40', 40" (step 122). The determination of an LPP is performed separately for each target media cluster on which the asset is not already stored. Finally, the process 120 adds the GPP and LPP to obtain the TPP associated with the asset and the particular target media cluster 40, 40', 40" (step 126).

Replication of an asset to a media cluster 40, 40', 40" involves copying replicas of the elements of the asset, which are not already present, onto the cluster's video data storage 36, 36', 36". On the same media cluster 40, 40', 40", replicas of different assets can share replicas of the asset

elements. Thus, replicas of asset elements already on a media cluster are not recopied onto the cluster during propagation of the asset to the cluster. Copying entails pulling elements of the asset, which are not already on the cluster, from the video data storage 36, 36', 36" of another media cluster 40, 40', 40" and writing the pulled elements to the video data storage 36, 36', 36" of the target media cluster 40, 40', 40". After deciding to propagate an asset to a media cluster 40, 40', 40", the propagation service module 66 updates RVs of the replicas of assets and asset elements on the target cluster 40, 40', 40".

Referring to FIG. 7, a process 140 for determining whether to propagate a selected asset to a target media cluster 40, 40', 40" is shown. The propagation service module 66 calculates a TPP for a replica of the selected asset on the target media cluster 40, 40', 40" (step 142). The TPP is the sum of the asset's GPP for propagating a new replica of the asset on the system 10 and the LPP for having a replica of the selected asset on the particular media cluster 40, 40', 40".

The propagation service module 66 selects a list of regions, e.g., combinations of ELists, of the target media cluster 40, 40', 40" that have smaller RVs than the TPP for the selected asset (step 144). The propagation service module 66 determines whether any regions on the list have a size sufficient to store replicas of the elements of the selected asset that are not already stored on the media cluster 40, 40', 40", i.e., replicas of the missing elements (step 146). If at least one such region exists, the propagation service module selects the most appropriate one of such regions (step 147). The most appropriate region is a region with the smallest RV and among regions with the smallest RV, the most appropriate region has the smallest size. The propagation

service module 66 replaces data in the selected region by replicas of the missing elements of the selected asset (step 148). The target region for the copying is the region from the list with the smallest RV and sufficient size to store the elements. During copying of the missing asset elements to the target cluster 40, 40', 40", the propagation service module 66 protects both source and destination replicas from deletion.

To copy the asset elements, the propagation service module 66 identifies a video data storage 36, 36', 36" of another media cluster 40, 40', 40" to act as a source for the elements being copied. The propagation service module 66 also fixes a minimum transfer rate for the elements being copied and protects the source and target from being overwritten during copying.

After ordering the replication of the selected asset, the propagation service module 66 also updates the RVs of replicas of asset elements remaining on the target media cluster 40, 40', 40" (step 150). Any replicas of asset elements not belonging to a full replica of an asset are updated to have RVs with low values, e.g., the value zero. Replicas of these asset elements will be the first elements removed to provide space for new replicas of assets.

If none of the listed regions has sufficient size to store the replicas of missing elements of the selected asset, the propagation service module 66 does not copy replicas of the missing asset elements to the target media cluster 40 (step 152).

#### Element Deletion Lists

FIG. 8A is a snapshot showing relationships between data objects stored on the video data storage 36 of one media cluster 40 shown in FIG. 1. The data objects include replicas

of asset elements A-H and replicas of assets 1-5, which are composed of the replicas of elements A-H. Each replica of an asset 1-4 has an associated RV, i.e., a number determining the asset replicas value with respect to being deleted. Each  
5 replica of an element A-H has an associated data size and an RV inherited from the assets to which the element belongs.

The replicas of elements A-H that belong to an asset are streamed from the media cluster 36 to a viewer in response to a viewing request. Thus, the absence of a replica of an  
10 element A-H belonging to the replica of the requested asset results in the asset being not streamable and thus, unusable for viewers. The deletion of the replica of any element A-H results in each replica of an asset 1-5, to which the deleted replica of the element A-H belonged, ceasing to exist. For  
15 this reason, the RV of a replica of an element is itself equal to a preselected combination of the RVs of the replicas of assets 1-5 to which the element A-H belongs, e.g., a sum of the RVs of replicas of such assets. For example, the shared element I has an RV of 30, which is the sum of the RVs of the  
20 replicas of assets 1 and 2 to which replica of element I belongs.

To free space on the video data storage 36, a replica of a selected element A-H can be deleted or overwritten. Each replica of an element A-H also defines an element deletion  
25 list (EList). An EList includes the additional replicas of elements A-H that can be deleted along with the selected replica of an element A-H without making additional replicas of assets of the media cluster 40 disappear. The EList of a selected asset includes replicas of all elements A-H that  
30 belong "only" to assets to which the selected replica of an element A-H belongs. For example, the EList for selected replica of an element H includes the replicas of elements H



and G. The replica of element G belongs to this EList, because it belongs only to the replicas of assets 4, 5 to which the selected replica of element H also belongs. Deletion of all replicas of elements A-H of an EList does not produce more loss of RV for the media cluster 40 than the RV loss produced by only deleting the selected replica of element A-H defining the EList. On the other hand, deleting all the replicas of assets in the EList of a selected replica of an asset often liberates more space for writing new replicas of assets to the media cluster 40.

FIG. 8B illustrates the ELists 1'-6' for the replicas of elements A-H and replicas of assets 1-5 shown in FIG. 8A. For each EList 1'-6', an RV and a size can be defined. FIG. 8B shows RV and size of each EList by labels RV/size. The RV of an EList 1'-6' is the preselected combination of the RVs of the replicas of assets 1-5 to which the ELists 1'-6' selected replica of an element A-H belongs. The size of an EList 1'-6' is a sum of the data sizes of the replicas of elements A-H that belong to the EList 1'-6'.

FIG. 9A is a table 160 whose entries characterize the ELists 1'-6' of the video data storage 36, shown in FIGs. 8A-8B. Each entry of table 160 provides an RV, size, and a list of replicas of elements A-I for one of the ELists 1'-6'. The last column 162 of the table 160 indicates which replicas of assets 1-5 will cease to exist on the associated media cluster 40 if the EList 1'-6' associated with the entry is deleted.

Fig. 8C shows the data objects remaining on the video data storage 36 after deletion of EList 3', shown in table 160. After the deletion, remaining ELists 2", 3" have forms that differ from the forms of any ELists 1'-6' prior to the deletion. Table 160' of FIG. 8D characterizes the ELists 1', 2", 3", 4' that remain after the above-described deletion.

Elements from several ELists can be deleted together to free regions of the video data storage for replicas of new asset elements. FIG. 9B shows a table 160" that provides region economic values, i.e., total RVs, and sizes of "combinations of ELists", which are formed from the ELists 1'-6' shown in FIG. 8B. The region values and sizes are found by combining RVs, e.g., by summing, and summing sizes, respectively, for the ELists 1'-6' belonging to the combinations. The table 160" lists the "combinations of ELists" in order of increasing replacement value up to a value of 50 where 50 is the largest TPP of assets currently under consideration for propagation.

From the ELists, the propagation service module 66 produces a table listing "combinations of ELists" for the media cluster 40. The table lists "combinations of ELists" whose total RVs are smaller than the maximum TPP of any asset being currently considered for propagation to the target cluster 40. To create the table, the propagation service module 66 searches the media cluster's table of ELists for combinations of ELists whose combined RVs are smaller than the maximum TPP of any asset considered for propagation to the target media cluster 40. Limiting searches to this upper bound on RVs reduces the number of "combinations of ELists" for which the propagation service module 66 needs to determine a total RV or region economic value.

FIG. 10 is a flow chart for a process 168 that decides whether a target media cluster 40, 40', 40" has space for a replica of a new selected asset not presently on the cluster 40, 40', 40". From the table listing "combinations of ELists", the process 168 selects the entries whose RVs are smaller than the TPP of the new selected asset (step 170). From these entries, the propagation service module 66 searches

for a "combination of ELists" that that occupy space large enough to store the replicas of elements of the selected new asset, which are not already on the media cluster (step 172). If several one or more such combinations exist, the

5 propagation service module 66 selects the "combination of ELists" whose RV is smallest. Among the combinations of ELists with smallest RVs, the propagation service module 66 selects the combination having the smallest data size, i.e., this combination of ELists defines the most appropriate  
10 storage region to delete. The data size must be sufficient to store replicas of elements of the selected new asset not already on the target media cluster 40, 40', 40". If the sought "combination of ELists" exists, the propagation service module 66 replaces elements of the new selected asset, not  
15 already on the media cluster, to the region previously occupied by the sought combination of ELists (step 174). After performing the copying, the propagation service module 66 updates RV of replicas of elements and asset elements on the media cluster 40, 40', 40" and the table of ELists (step  
20 176). If the sought combination of ELists does not exist, the propagation service module 66 does not copy missing elements of the new selected asset to the target media cluster 40, 40', 40" (step 178).

#### 25 Global and Local Propagation Priorities

The TPP for replicating an asset is a sum of a global propagation priority (GPP) and a local propagation priority. The GPP is independent of target media cluster 40, 40', 40". The LPP depends on the target media cluster 40, 40', 40".

30 Each GPP is a sum of several components, which may take values from 0 to 100. Each component may separately vary in

time thereby changing the probability of propagating a replica of the asset to new media clusters 40, 40', 40".

FIG. 11 shows a flow chart for a process 180 that initially defines and subsequently updates the GPP of a new asset. When a new asset first becomes active in the system 10, the process 180 assigns the new asset to a usage class of similar assets (step 182). Membership to usage classes may be based on an asset's genre, e.g., a subject classification such as newly released movies or sports events, or may be based on other criteria such as anticipated popularity. The process 180 assigns an initial GPP to the new asset based, in part, on the usage class of which the asset is a member (step 184).

After being assigned a GPP, replicas of the new asset may be propagated to new media clusters 40, 40', 40" based on the TPP, i.e., the  $TPP = GPP + LPP$  (step 186). While the asset is available to viewers, the associated GPP is updated over time to match the actual viewer usage (step 188). Media clusters 40, 40', 40" having replicas of assets report usage data to the connection management module 68, which reports the data to propagation service module 66. Using the data, the propagation service module 66 recalculates the GPP of the asset.

Since the updated GPP partially determines to which media clusters 40, 40', 40" an asset propagates, the distribution of the asset on the media clusters 40, 40', 40" changes in response to usage data fed back to the propagation service module 66. Gradually, the GPP is adjusted to reflect, in part, relative viewer requests for the asset as compared to viewer requests for other assets.

The propagation service module 66 uses usage data to update the value of the usage pattern of the usage class to which the asset is a member (step 190).

The viewer usage data may be determined from values of counters 162, shown in FIG. 3, associated with individual assets. The counters 162 record demands for individual ones of the assets. The usage data accumulated by these counters  
5 162 is described below.

One of the counters 162 measures use of each asset during specific times of week. A set of accumulators is maintained to actually indicate use of each asset during every 2 hour interval of the week. For example, one of these counters may  
10 store data indicating that the Tuesday night news is most requested on Wednesday morning. The accumulator corresponding to the current time of week is one of the counters 162. The usage data for a usage class, as described above, for a new asset is maintained by an analogous set of counters and  
15 accumulators.

Usage data is accumulated on short-term viewer demand, medium-term viewer demand, total number of viewer requests, and last-request-time for each asset. The counters 162 (FIG. 3) accumulate usage data, which are associated with individual  
20 replicas of assets on media clusters 40, 40', 40".

Another of the counters 162 measures the "short-term demand" for an associated asset by counting each viewer request for the asset. The propagation service module 66 may decrement this counter 162 by a fixed amount every few hours  
25 or perform another counter correction to make the counter's total count indicative of the number of "recent" requests. The count is never decremented to negative values. If the accumulated count is high, the propagation priority, i.e., value of putting another replica of the asset onto a media  
30 cluster 40 is high, and the propagation service module 66 increases the asset's TPP.

The medium-term demand for each asset is measured by seven of the counters 162, which accumulate numbers of demands for the asset over weeklong periods. The period of each counter ends on different day. For each counter, the count from the present week is compared to the count from the same counter for the last week. A decrease in this count indicates a declining interest for the asset, and the propagation service module 66 reduces the GPP of the asset in response to such decreases.

Other counters 162 measure the total number of requests and time of the last request for each asset. These counts track popularities of assets. The total number of requests may be used to update the GPP of the asset to generally reflect its popularity. The lengths of time since last request for different assets are compared to determine relative asset popularities.

The GPP of an asset may depend on other components. One component measures whether an asset is a rapid mover, e.g., an asset whose usage changes suddenly. Another component raises the GPP of assets for which only one replica exists. This favors generation of a second replica, which is valuable to the system to avoid failures. Another component raises the GPP of assets whose one or more replicas are only accessible through heavily loaded delivery networks. This favors adding a second replica, which can offset unavailability of the asset caused by other video streaming traffic.

The LPP assigned to a replica of an asset is also a sum of several components, but the components depend on properties of a server's local environment. Each of the components may take a value in a preselected range, e.g., 0 to 100. The components contributing to LPP cause the propagation service module 66 to distribute replicas of assets to media clusters

40 a manner that accounts, in part, for local viewing preferences.

One component of LPPs depends on the classification of an asset, e.g., genre and language. This component causes  
5 distributions of replica of assets to accord with local preferences of viewers and may be updated by historical viewing data. Counters 162 of the propagation service module 66 accumulate numbers of viewer requests for various classes of assets for use in determining the value of this component.

10 Another component of LPPs depends on whether multiple replicas of the asset are stored on the set of media clusters 40, 40', 40". This component is high for clusters 40, 40', 40" not storing a replica of the asset if a replica of the asset is only on one cluster 40, 40', 40". This component  
15 stimulates the propagation service module 66 to replicate each asset present on one media cluster 40, 40', 40" onto a second media cluster 40, 40', 40". The second replica helps to avoid delivery failures caused by hardware failures.

Another component to LPPs depends on activity levels of  
20 media clusters 40 increasing the LPP for replicas of new assets only located on other media clusters 40, 40', 40" that are heavily loaded. The component causes the propagation service module 66 to copy a replica of the asset to a less busy media cluster 40, 40', 40" if current replicas of the  
25 asset are on media clusters 40 operating at near capacity. The propagation service module 66 uses delivery pathway data from the connection manager 68 to determine whether media clusters 40, 40', 40" are operating at near capacity.

Another component to LPPs depends on activity levels of  
30 delivery pathways. This component causes the propagation service module 66 to copy a replica of an asset onto a media cluster 40 that is connected to a node group 20, 20', 20",

20''' by less burdened delivery pathway if the presently usable delivery pathways are near capacity. The loading of each delivery pathway is determined by the connection manager 68, which provides an abstracted view of the deliver pathways to the propagation service module 66.

Another component to LPPs causes the propagation service module 66 to copy a replica of an asset to a new media cluster 40, 40', 40" if present replicas are inaccessible to some users. The inaccessibility may result from the absence of delivery pathways from the clusters 40, 40', 40" presently storing a replica of the asset and the node groups 20, 20', 20", 20''' without access.

In various embodiments, other historical usage data is used to set the values of the GPPs and LPPs of potential propagations. The propagation of viewing assets to media clusters 40, 40', 40" is calculated to increase the total economic value of the assets to the system 10, e.g., by increasing viewer payments for movie rentals. As viewer demands change, the propagation priorities assigned to replicas of assets are updated to follow the changing demands. Asset propagation evolves the distribution of replicas of the assets on the media clusters 40, 40', 40" in response to the updates to GPP and LPP. Thus, changes in viewing preferences automatically induce an evolution in the distribution of viewing assets and, at least partially, follows the viewing preferences.

The retention values (RVs) assigned to replicas of assets and to replicas of asset elements, which are both stored on the media clusters 40, 40', 40", are calculated and updated through processes analogous to the processes used to determine the TPP. The RV may be a sum of a global value and a local value. The global value indicates an economic value



associated with retaining the present set of replicas of the  
asset on the entire collection of media clusters 40, 40', 40".  
The local value indicates an economic value associated with  
retaining the replica of the asset on a particular associated  
5 media cluster 40, 40', 40". Both the local and global values  
may be sums of components of the same types as the components  
contributing to LPP and GPP, but coefficients may vary. The  
global and local values may depend on collected usage data and  
be assigned to usage classes that contribute to defining  
10 initial values.

Other additions, subtractions, and modifications of the  
described embodiments may be apparent to one practiced in this  
field.

What is claimed is:

1. A process of propagating viewing assets to a system of video servers, comprising:

copying a missing portion of a replica of a selected viewing asset to a target video server in response to  
5 determining that a priority to propagate the selected asset to the target server is higher than a retention value of a replica of one or more viewing assets stored on the target server.

10 2. The process of claim 1, wherein the copying writes the missing portion of the replica of the selected asset onto a storage region of the target video server previously storing a portion of the replica of one or more viewing assets.

15 3. The process of claim 1, further comprising:  
selecting a portion of the replica of one or more viewing assets in response to the replica of one or more viewing assets having a data size at least as large as a data size of the missing portion of the selected asset.

20 4. The process of claim 1, wherein the copying the missing portion of the replica of a selected asset includes copying the missing portion from one or more video servers.

25 5. The process of claim 1, further comprising :  
assigning propagate priorities of a plurality of viewing assets;

ranking the viewing assets according to the assigned priorities; and

30 selecting the selected asset in response to the selected asset having more than a preselected minimum rank.

6. The process of claim 5, wherein the assigning includes determining the propagation priorities based at least in part on global priorities to propagate associated ones of the assets to target video servers.

7. The process of claim 5, wherein the assigning includes determining local priorities to have replicas of associated assets on particular video servers, the local priorities depending on the states of the particular video servers.

8. The process of claim 5, wherein the portion of replica of one or more viewing assets consists of replicas of asset elements belonging to one or more ELists.

9. The process of claim 3, further comprising:  
updating retention values of replicas of viewing assets remaining on the target server in response to the copying.

10. The process of claim 1, wherein the viewing assets include video files for at least one of movies, news emissions, and shopping emissions.

11. The process of claim 1, wherein the replica of one or more viewing assets includes a replica of an asset element shared by replicas of two assets on the target server.

12. A process for propagating digital viewing assets to video servers, comprising:

assigning to each of a plurality of digital viewing assets a priority to propagate the asset onto video servers;  
ranking the assets based on the assigned priorities; and

propagating one of the assets to one or more selected video servers in response to the one of the assets having a preselected minimum ranking.

5           13. The process of claim 12, wherein the assigning includes:

          assigning a viewing asset to a usage class, the usage class providing a portion of an initial value for priorities to propagate assets assigned to the class.

10           14. The process of claim 13, further comprising:

          accumulating usage data on individual assets stored on the video servers; and

          updating the priorities to propagate the assets based on  
15 the usage data.

          15. The process of claim 13, wherein the viewing assets include one of encoded digital video assets and encoded digital audio assets.

20           16. The process of claim 14, wherein the usage data includes numbers of viewer requests during predetermined periods and differences between numbers of viewer requests during earlier and later predetermined periods.

25           17. The process of claim 14, further comprising:

          updating the priority to propagate a particular asset in the usage class based on a difference between the usage level of the usage class and a usage level of the particular asset  
30 determined from the accumulated usage data.

          18. The process of claim 13, further comprising:

calculating the priority to propagate the one of the  
assets onto a particular video server from a global priority  
to propagate the one of the assets and a local priority to  
propagate a replica of the asset on the one of the selected  
5 video servers.

19. The process of claim 13, further comprising:

streaming a replica of the copied one of the assets from  
the particular video server to a television of a viewer in  
10 response to receiving a request to view the asset from the  
viewer.

20. A process of propagating viewing assets to a video  
storage, comprising:

15 assigning propagation priorities to viewing assets;  
constructing a table of element deletion lists for a  
target video storage;

selecting a group of element deletion lists from the  
table, the group having a data size at least as large as a  
20 data size of a portion of a replica of another asset not  
stored on the target storage; and

copying the portion of the replica of the another asset  
onto the target video storage in response to the propagation  
priority of the another asset being larger than a retention  
25 value of the group.

21. The process of claim 20, wherein the copying writes  
the portion onto a region of the target video storage  
previously storing the group.

22. The process of claim 20, wherein the selecting a  
group includes constructing a table listing sets of element

deletion lists with lower retention value than the propagation priority of the another asset.

23. The process of claim 22, wherein the selecting  
5 includes picking one of the lists having a data size at least as large as the portion of the replica of the another asset.

24. The process of claim 20, further comprising:  
updating the table of element deletion lists in response  
10 to performing the copying.

25. The process of claim 20, wherein each element  
deletion list includes a set of replicas of asset elements  
that are shared by the same assets.  
15

26. A process of distributing viewing assets to viewers,  
comprising:  
assigning priorities to assets, the priorities indicating  
priorities for distributing the associated assets to video  
20 servers accessible to viewers;  
selecting a video server; and  
copying one of the assets onto the video server in  
response to determining that the priority associated with the  
one of the assets is greater than a retention value associated  
25 with a set replicas of viewing assets stored on the video  
server, the replicas occupying enough space to store the one  
of the assets.

27. The process of claim 26, wherein the copying  
30 includes searching for one or more sets of replicas of asset  
elements to delete from a table of element deletion lists.

28. The process of claim 26, further comprising:  
updating the retention values in response to anticipated  
changes in viewer request levels for assets.

5 29. The process of claim 28, further comprising:  
accumulating data on usage of individual ones of the  
assets, the updating based at least in part on the accumulated  
data.

10 30. An interactive television system, comprising:  
one of a network and a bus;  
a plurality of video servers to store digital replicas of  
viewing assets for viewers, the video servers being connected  
by the one of a network and a bus; and

15 a control unit connected to the video servers and  
configured to control copying of a missing portion of a  
replica of a selected asset to one of the video servers in  
response to a priority to propagate the selected asset onto  
the target server being higher than a value of retaining a  
20 replica of one or more other assets already stored on the one  
of the servers.

25 31. The system of claim 30, wherein the control unit is  
further configured to record usage data for the assets stored  
on each of the local video storages.

32. The system of claim 30, further comprising:  
a plurality of distribution networks to provide channels  
for delivering viewing assets to viewer televisions, each  
30 distribution network connected to portion of the video  
servers.

33. The system of claim 30, wherein the control unit is configured to accumulate usage data on viewing assets from the video servers.

5 34. A program storage media storing computer executable instructions for propagating viewing assets onto video storages, the instructions to cause the computer to:

order copying of a missing portion of a replica of a selected viewing asset to a target video server in response to  
10 determining that a priority to propagate the selected asset to the target server is higher than a retention value of a replica of one or more viewing assets stored on the target server.

15 35. The media of claim 34, the instructions further causing the computer to:

select a portion of the replica of one or more viewing assets in response to the replica of one or more viewing assets having a data size at least as large as a data size of  
20 the missing portion of the selected asset.

36. The media of claim 34, wherein the instructions to order copying of the missing portion of the replica of a selected asset cause the computer to control copying of the  
25 missing portion from one or more video servers.

37. The media of claim 34, the instructions further causing the computer to:

assign priorities to propagate to a plurality of viewing  
30 assets;

rank the viewing assets according to the assigned priorities; and



select the selected asset in response to the selected asset having more than a preselected minimum rank.

38. The media of claim 37, wherein the instructions to  
5 assign cause the computer to:

determine the propagation priorities based at least in part on global priorities to propagate associated ones of the assets to target video servers.

39. The media of claim 37, wherein the portion of  
10 replica of one or more viewing assets consists of replicas of asset elements belonging to one or more ELists.

40. The media of claim 35, the instructions further  
15 causing the computer to:

update retention values of replicas of viewing assets remaining on the target server in response to the copying.

41. A program storage media storing executable  
20 instructions for propagating digital viewing assets onto video servers, the instructions causing a computer to:

assign to each of a plurality of digital viewing assets a priority to propagate the asset onto video servers;

rank the assets based on the assigned priorities; and

25 order propagation of one of the assets to one or more selected video servers in response to the one of the assets having a preselected minimum ranking.

42. The media of claim 41, wherein the instructions to  
30 assign cause the computer to:

assign a viewing asset to a usage class, the usage class providing a portion of an initial value for priorities to propagate assets assigned to the class.

5           43. The media of claim 42, the instructions further causing the computer to:

accumulate usage data on individual assets stored on the video servers; and

10           update the priorities to propagate the assets based on the usage data.

15           44. The media of claim 43, wherein the usage data includes numbers of viewer requests during predetermined periods and differences between numbers of viewer requests during earlier and later predetermined periods.

45. The media of claim 43, the instructions further causing the computer to:

20           update the priority to propagate a particular asset in the usage class based on a difference between the usage level of the usage class and a usage level of the particular asset determined from the accumulated usage data.

25           46. The media of claim 42, the instructions further causing the computer to:

30           calculate the priority to propagate the one of the assets onto a particular video server from a global priority to propagate the one of the assets and a local priority to propagate a replica of the asset on the one of the selected video servers.

47. A program storage media storing executable instructions for propagating viewing assets to a video storage, the instructions causing a computer to:

assign propagation priorities to viewing assets;

5       construct a table of element deletion lists for a target video storage;

select a group of element deletion lists from the table, the group having a data size at least as large as a data size of a portion of a replica of another asset not stored on the  
10       target storage; and

order copying of the portion of the replica of the another asset onto the target video storage in response to the propagation priority of the another asset being larger than a retention value of the group.

15       48. The media of claim 47, wherein the instructions to select a group cause the computer to construct a table listing sets of element deletion lists with lower retention value than the propagation priority of the another asset.

20       49. The media of claim 48, wherein the instructions to select cause the computer to pick one of the lists having a data size at least as large as the portion of the replica of the another asset.

25       50. The media of claim 47, wherein each element deletion list includes a set of replicas of asset elements that are shared by the same assets.

30       51. A process for propagating digital viewing assets to video servers, comprising:

propagating a plurality of viewing assets to video servers based on priorities to propagate, the priorities providing a ranking of the assets;

accumulating usage data on individual ones of the assets  
5 stored on the video servers; and  
updating the priorities based on the usage data.

52. The process of claim 51, further comprising:

assigning a viewing asset to a usage class, the usage  
10 class providing a portion of an initial value for the  
priorities to propagate for the assets assigned to the class.

53. The process of claim 52, further comprising:

calculating the priority to propagate a selected one of  
15 the assets onto one of the video servers from a global  
priority to propagate the selected one of the assets and a  
local priority to propagate a replica of the selected one of  
the assets onto the one of the video servers.

54. The process of claim 53, wherein the global priority  
20 is based in part on a counter value, the counter value  
measuring usage of the selected one of the assets.

55. The process of claim 53, wherein the local priority  
25 is based in part on a bandwidth for streaming the selected one  
of the assets from the one of the video servers to a set of  
viewers.

**CONTENT PROPAGATION IN INTERACTIVE TELEVISION**

**ABSTRACT**

A process of propagates viewing assets on a system of video storages. The process includes copying a missing  
5 portion of a replica of a selected viewing asset onto a target video server. The act of copying is responsive to determining that a priority to propagate the selected asset to the target server is higher than a retention value of a replica of one or more viewing assets stored on the target server.

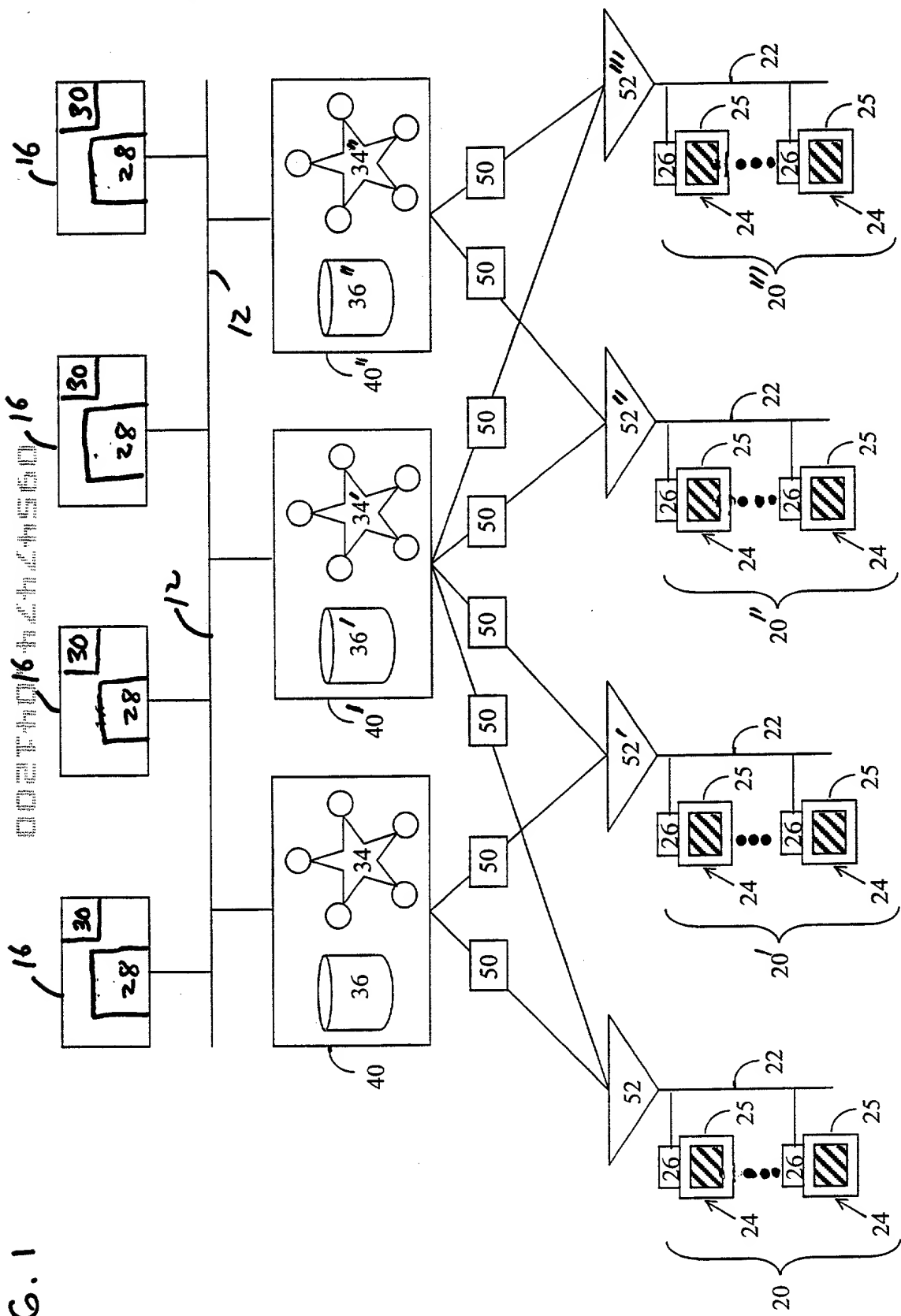
10 20022321.doc

002740-444560

FIG. 1

DATE 01/06/2004

10





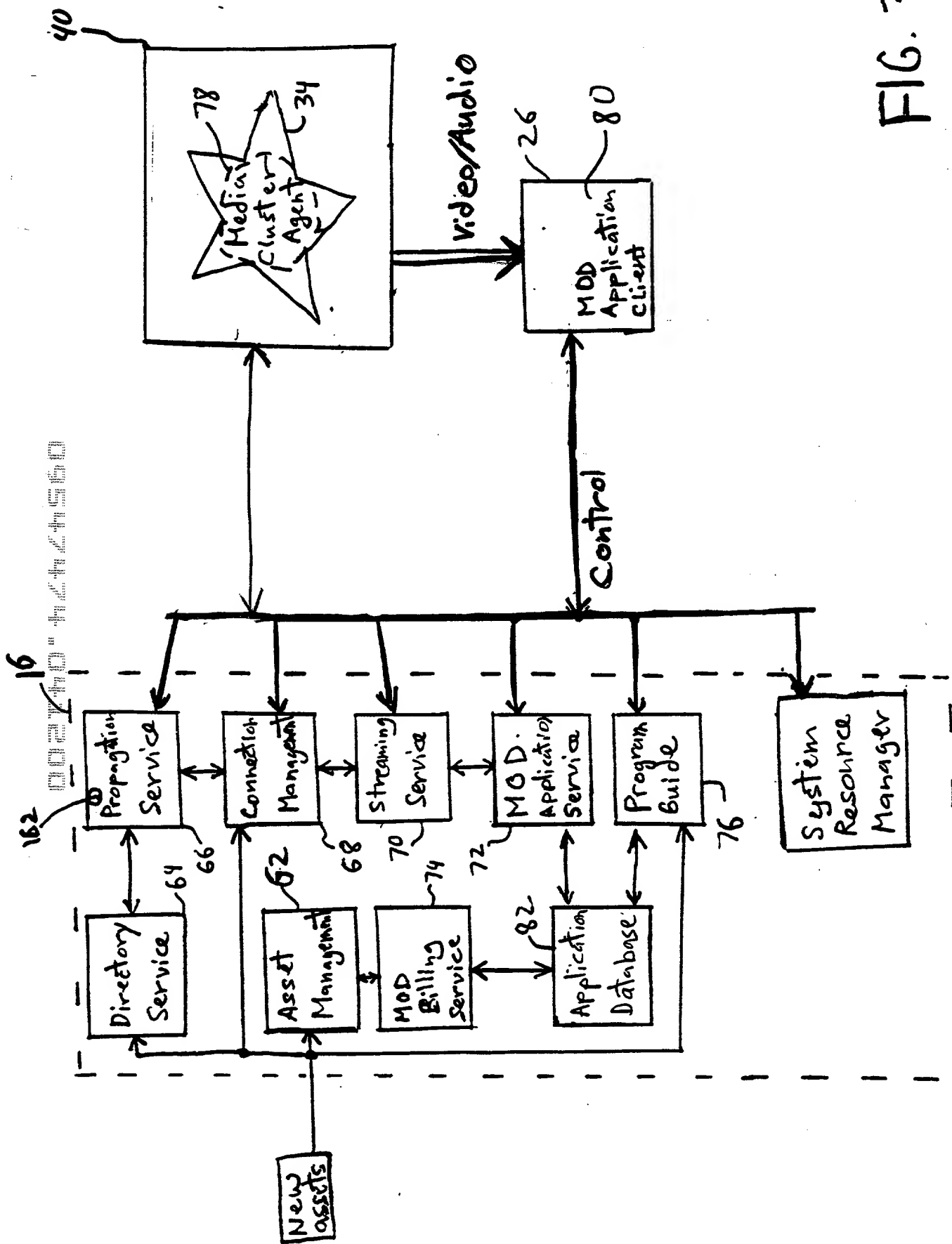


FIG. 3



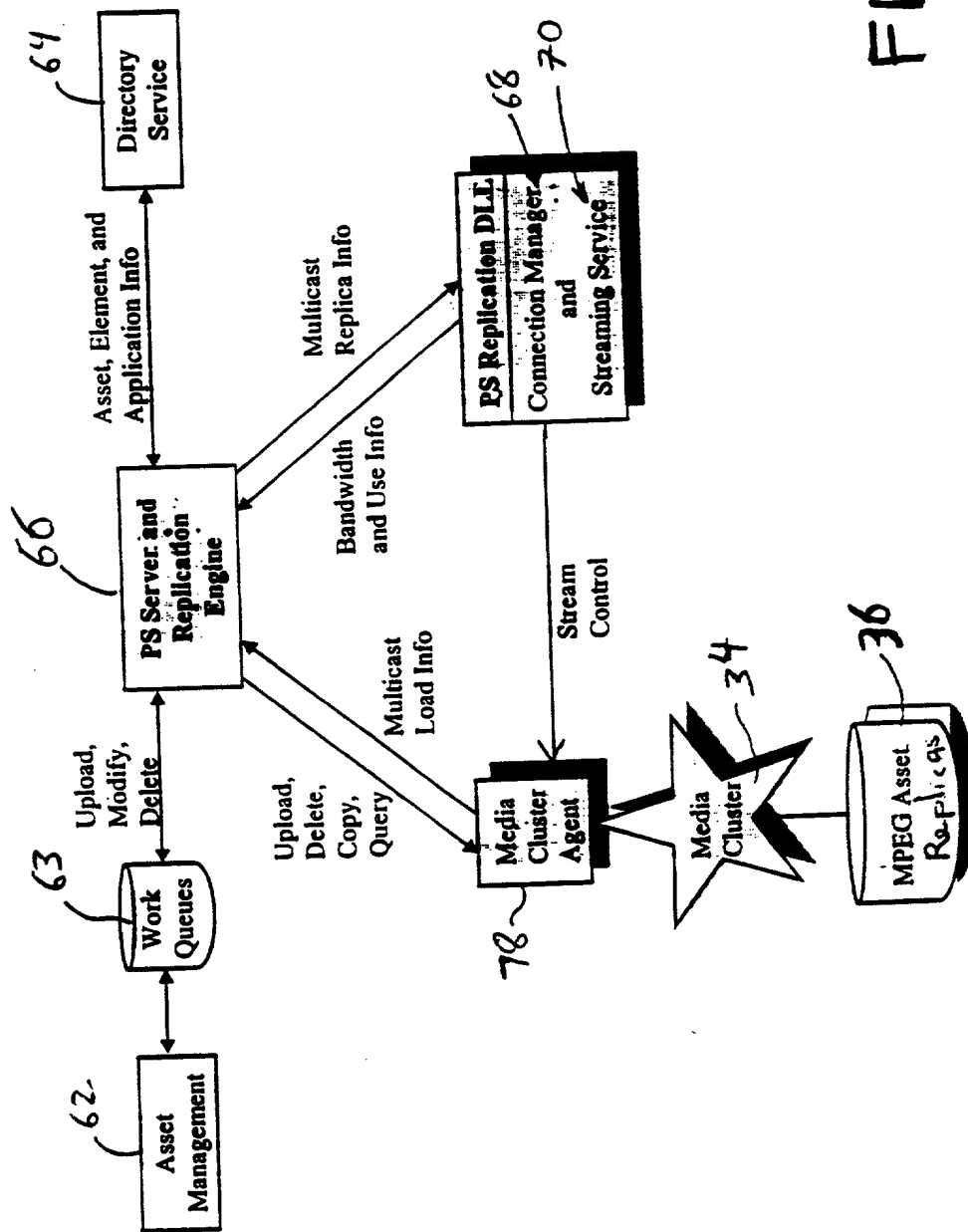


FIG. 4

	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050	2051	2052	2053	2054	2055	2056	2057	2058	2059	2060	2061	2062	2063	2064	2065	2066	2067	2068	2069	2070	2071	2072	2073	2074	2075	2076	2077	2078	2079	2080	2081	2082	2083	2084	2085	2086	2087	2088	2089	2090	2091	2092	2093	2094	2095	2096	2097	2098	2099	2100	2101	2102	2103	2104	2105	2106	2107	2108	2109	2110	2111	2112	2113	2114	2115	2116	2117	2118	2119	2120	2121	2122	2123	2124	2125	2126	2127	2128	2129	2130	2131	2132	2133	2134	2135	2136	2137	2138	2139	2140	2141	2142	2143	2144	2145	2146	2147	2148	2149	2150	2151	2152	2153	2154	2155	2156	2157	2158	2159	2160	2161	2162	2163	2164	2165	2166	2167	2168	2169	2170	2171	2172	2173	2174	2175	2176	2177	2178	2179	2180	2181	2182	2183	2184	2185	2186	2187	2188	2189	2190	2191	2192	2193	2194	2195	2196	2197	2198	2199	2200	2201	2202	2203	2204	2205	2206	2207	2208	2209	2210	2211	2212	2213	2214	2215	2216	2217	2218	2219	2220	2221	2222	2223	2224	2225	2226	2227	2228	2229	2230	2231	2232	2233	2234	2235	2236	2237	2238	2239	2240	2241	2242	2243	2244	2245	2246	2247	2248	2249	2250	2251	2252	2253	2254	2255	2256	2257	2258	2259	2260	2261	2262	2263	2264	2265	2266	2267	2268	2269	2270	2271	2272	2273	2274	2275	2276	2277	2278	2279	2280	2281	2282	2283	2284	2285	2286	2287	2288	2289	2290	2291	2292	2293	2294	2295	2296	2297	2298	2299	2300	2301	2302	2303	2304	2305	2306	2307	2308	2309	2310	2311	2312	2313	2314	2315	2316	2317	2318	2319	2320	2321	2322	2323	2324	2325	2326	2327	2328	2329	2330	2331	2332	2333	2334	2335	2336	2337	2338	2339	2340	2341	2342	2343	2344	2345	2346	2347	2348	2349	2350	2351	2352	2353	2354	2355	2356	2357	2358	2359	2360	2361	2362	2363	2364	2365	2366	2367	2368	2369	2370	2371	2372	2373	2374	2375	2376	2377	2378	2379	2380	2381	2382	2383	2384	2385	2386	2387	2388	2389	2390	2391	2392	2393	2394	2395	2396	2397	2398	2399	2400	2401	2402	2403	2404	2405	2406	2407	2408	2409	2410	2411	2412	2413	2414	2415	2416	2417	2418	2419	2420	2421	2422	2423	2424	2425	2426	2427	2428	2429	2430	2431	2432	2
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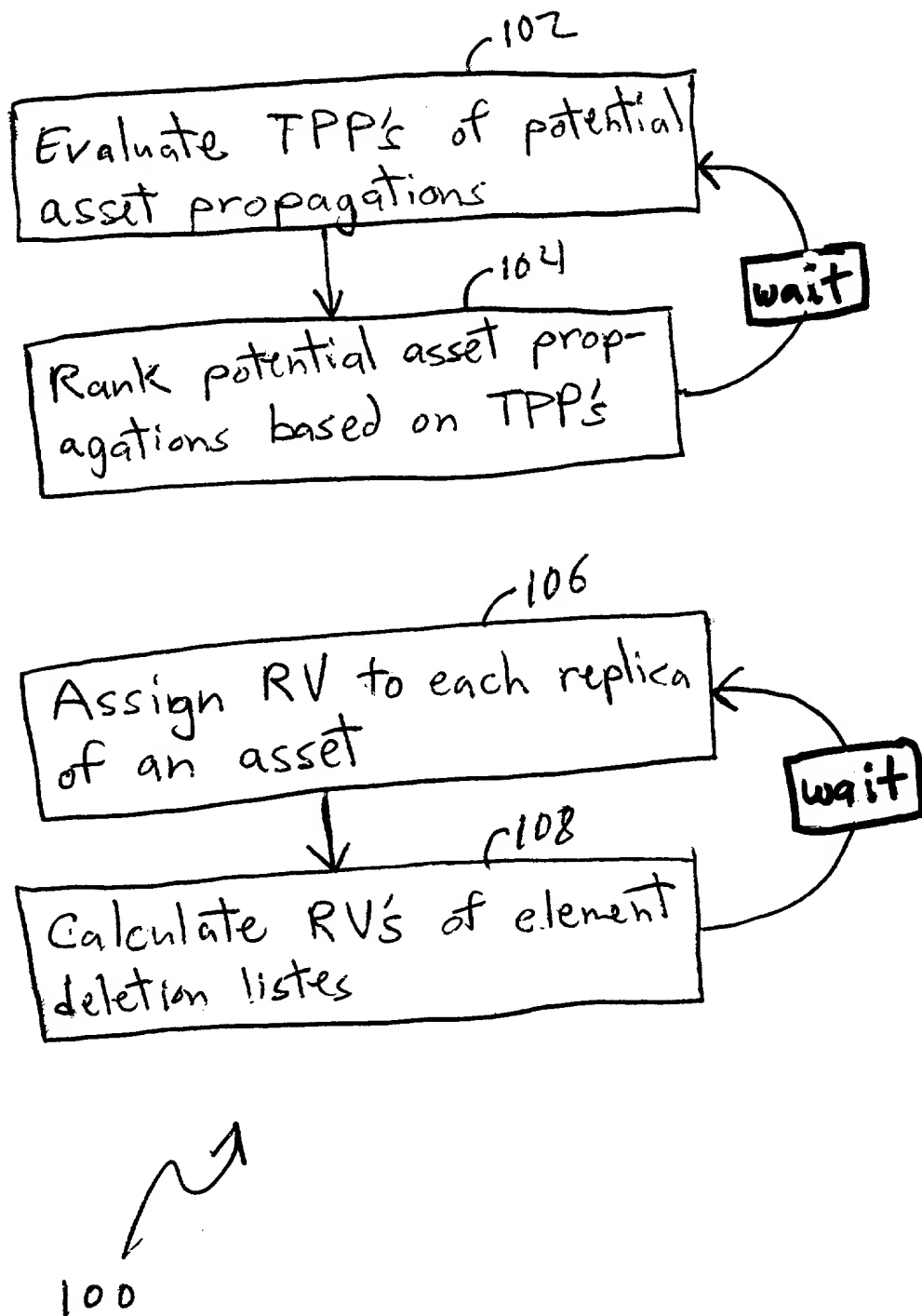


FIG. 5A

102

Evaluate TPP's of potential asset propagations

104

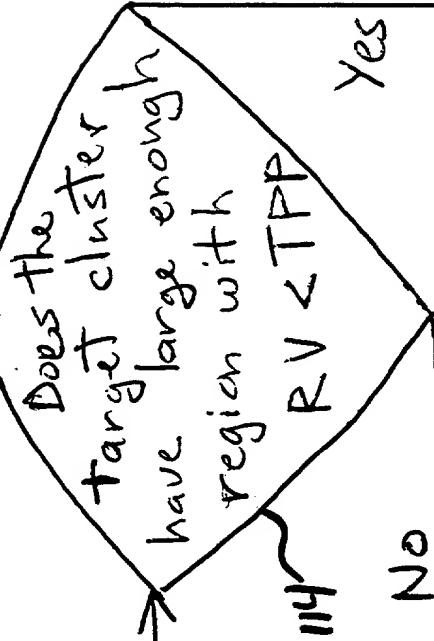
Rank potential propagations by TPP's

112

Select highest ranked potential propagation that remains

108

Calculate RV's of element deletion lists



116

Select most appropriate region; replace existing replicas of elements with missing replicas of elements; and update RV's, ELISTS, and combinations of ELISTS for the target media cluster

118



110

FIG. 5B

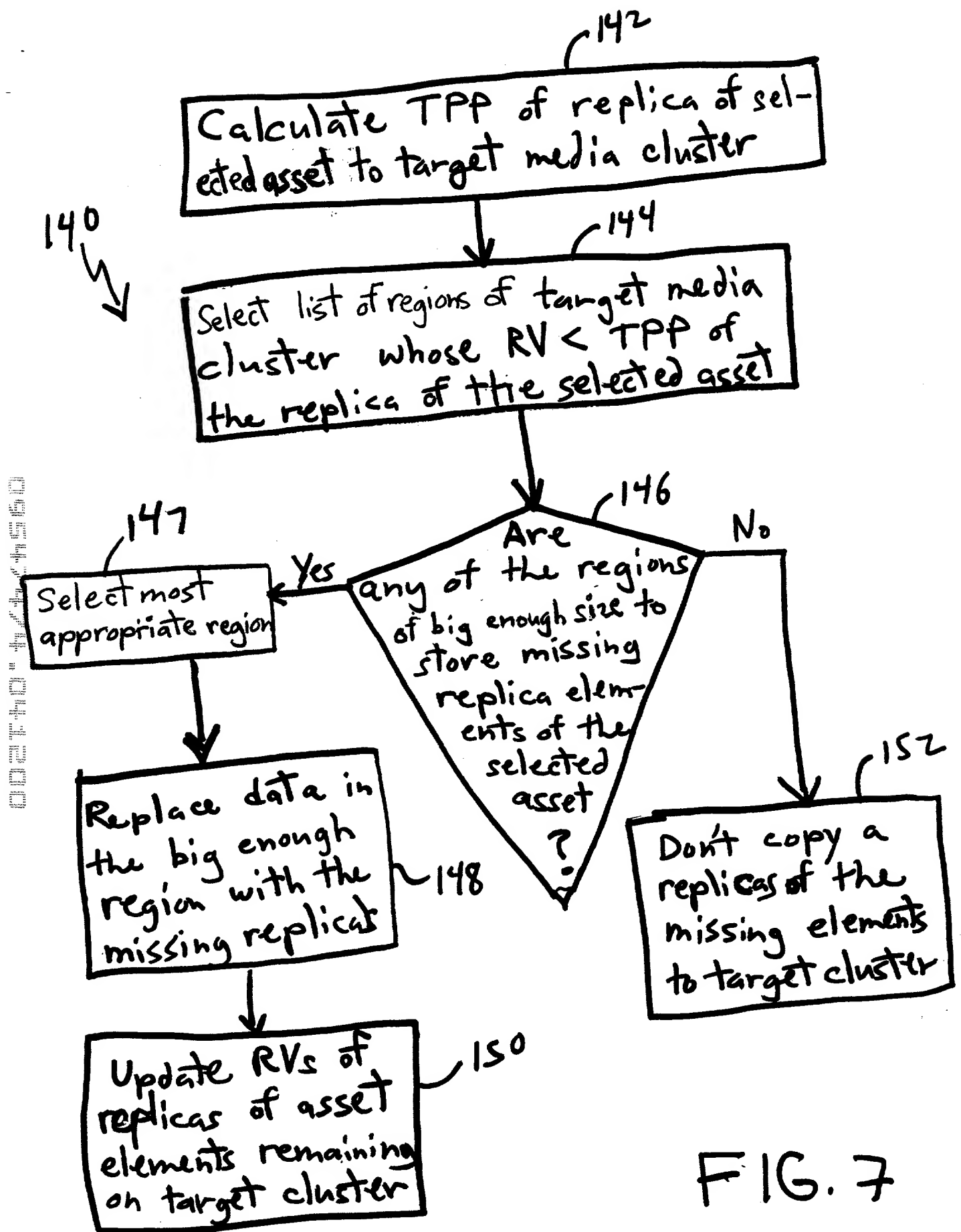
122  
Determine a GPP for an asset

124  
Determine the LPP for replicating the asset to a particular media cluster

126  
Calculate  $TPP = GPP + LPP$  for propagating the asset to the particular media cluster

120

FIG. 6



002740" 42724560

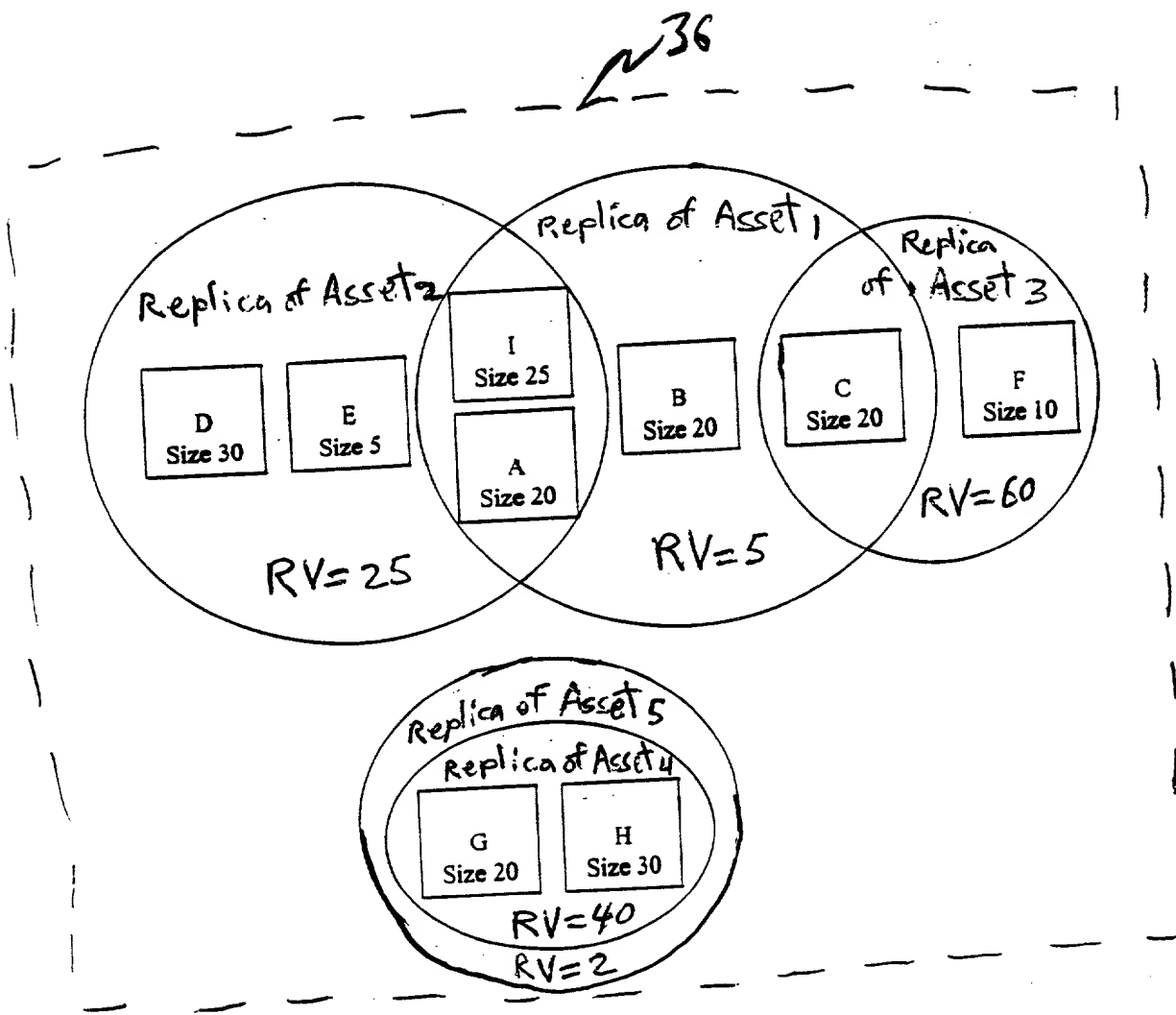


FIG. 8A

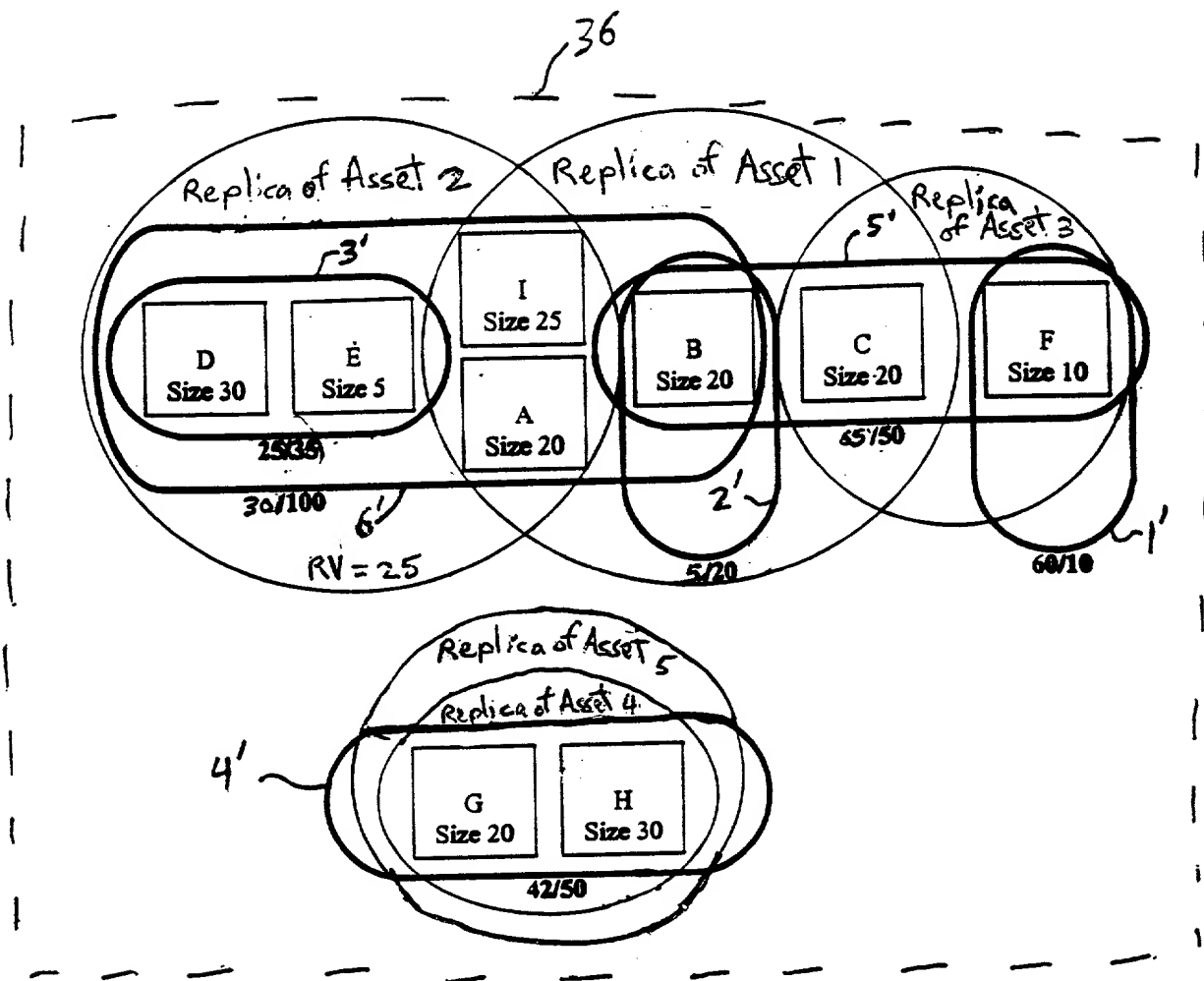


FIG. 8B

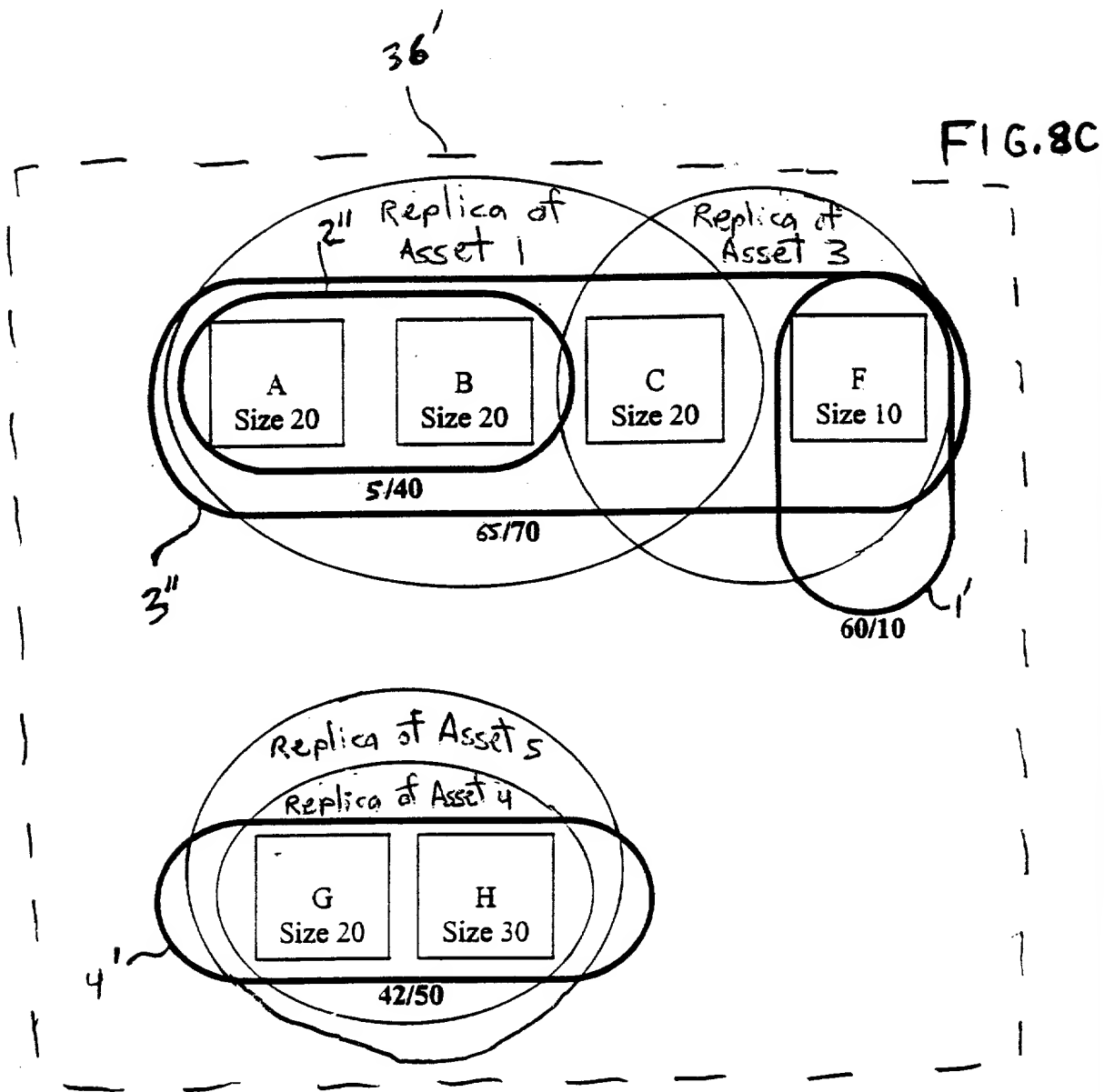


FIG. 8D

160'

EList ID	Selected Element	RV	Size	Elements	Assets
1'	F	60	10	F	3
2"	A or B	5	40	A, B	1
4'	G or H	42	50	G, H	4, 5
3"	C	65	70	A, B, C, F	1, 3



160

162

160"

EList IDs	Total RV	Total Size
2'	5	20
3'	25	35
2',3'	30	55
6'	30	100
2',6'	35	120
4'	42	50
2',4'	47	70

Variable	Mean	SD	Min	Max
Age	34.5	10.2	18	65
Gender	Male	10.5	0	20
Marital status	Married	15.2	0	30
Education	High school	12.8	0	25
Occupation	Unemployed	18.5	0	35
Income	Low	15.0	0	30
Health status	Good	12.0	0	25
Smoking status	Non-smoker	10.0	0	20
Alcohol consumption	Non-drinker	10.0	0	20
Exercise frequency	Low	10.0	0	20
Stress level	Low	10.0	0	20
Sleep quality	Good	12.0	0	25
Dietary habits	Healthy	12.0	0	25
Family size	Small	10.0	0	20
Religious beliefs	Religious	10.0	0	20
Community involvement	Active	10.0	0	20
Life satisfaction	High	12.0	0	25
Overall health	Good	12.0	0	25
Physical activity	Low	10.0	0	20
Mental health	Good	12.0	0	25
Social support	High	12.0	0	25
Work-life balance	Good	12.0	0	25
Financial stability	Good	12.0	0	25
Personal growth	High	12.0	0	25
Life goals	Clear	12.0	0	25
Resilience	High	12.0	0	25
Emotional stability	High	12.0	0	25
Self-esteem	High	12.0	0	25
Optimism	High	12.0	0	25
Gratitude	High	12.0	0	25
Forgiveness	High	12.0	0	25
Compassion	High	12.0	0	25
Patience	High	12.0	0	25
Kindness	High	12.0	0	25
Generosity	High	12.0	0	25
Humility	High	12.0	0	25
Modesty	High	12.0	0	25
Shyness	Low	10.0	0	20
Introversion	Low	10.0	0	20
Extroversion	High	12.0	0	25
Sensitivity	Low	10.0	0	20
Emotional stability	High	12.0	0	25
Neuroticism	Low	10.0	0	20
Conscientiousness	High	12.0	0	25
Openness	High	12.0	0	25
Agreeableness	High	12.0	0	25
Self-discipline	High	12.0	0	25
Time management	Good	12.0	0	25
Organization	Good	12.0	0	25
Productivity	High	12.0	0	25
Focus	High	12.0	0	25
Attention span	Long	12.0	0	25
Memory	Good	12.0	0	25
Learning ability	High	12.0	0	25
Creativity	High	12.0	0	25
Innovation	High	12.0	0	25
Problem-solving	High	12.0	0	25
Decision-making	Good	12.0	0	25
Leadership	High	12.0	0	25
Teamwork	Good	12.0	0	25
Communication	Good	12.0	0	25
Interpersonal skills	Good	12.0	0	25
Conflict resolution	Good	12.0	0	25
Stress management	Good	12.0	0	25
Emotional regulation	Good	12.0	0	25
Self-awareness	High	12.0	0	25
Empathy	High	12.0	0	25
Compassion	High	12.0	0	25
Kindness	High	12.0	0	25
Generosity	High	12.0	0	25
Humility	High	12.0	0	25
Modesty	High	12.0	0	25
Shyness	Low	10.0	0	20
Introversion	Low	10.0	0	20
Extroversion	High	12.0	0	25
Sensitivity	Low	10.0	0	20
Emotional stability	High	12.0	0	25
Neuroticism	Low	10.0	0	20
Conscientiousness	High	12.0	0	25
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Agreeableness	High	12.0	0	25
Self-discipline	High	12.0	0	25
Time management	Good	12.0	0	25
Organization	Good	12.0	0	25
Productivity	High	12.0	0	25
Focus</				

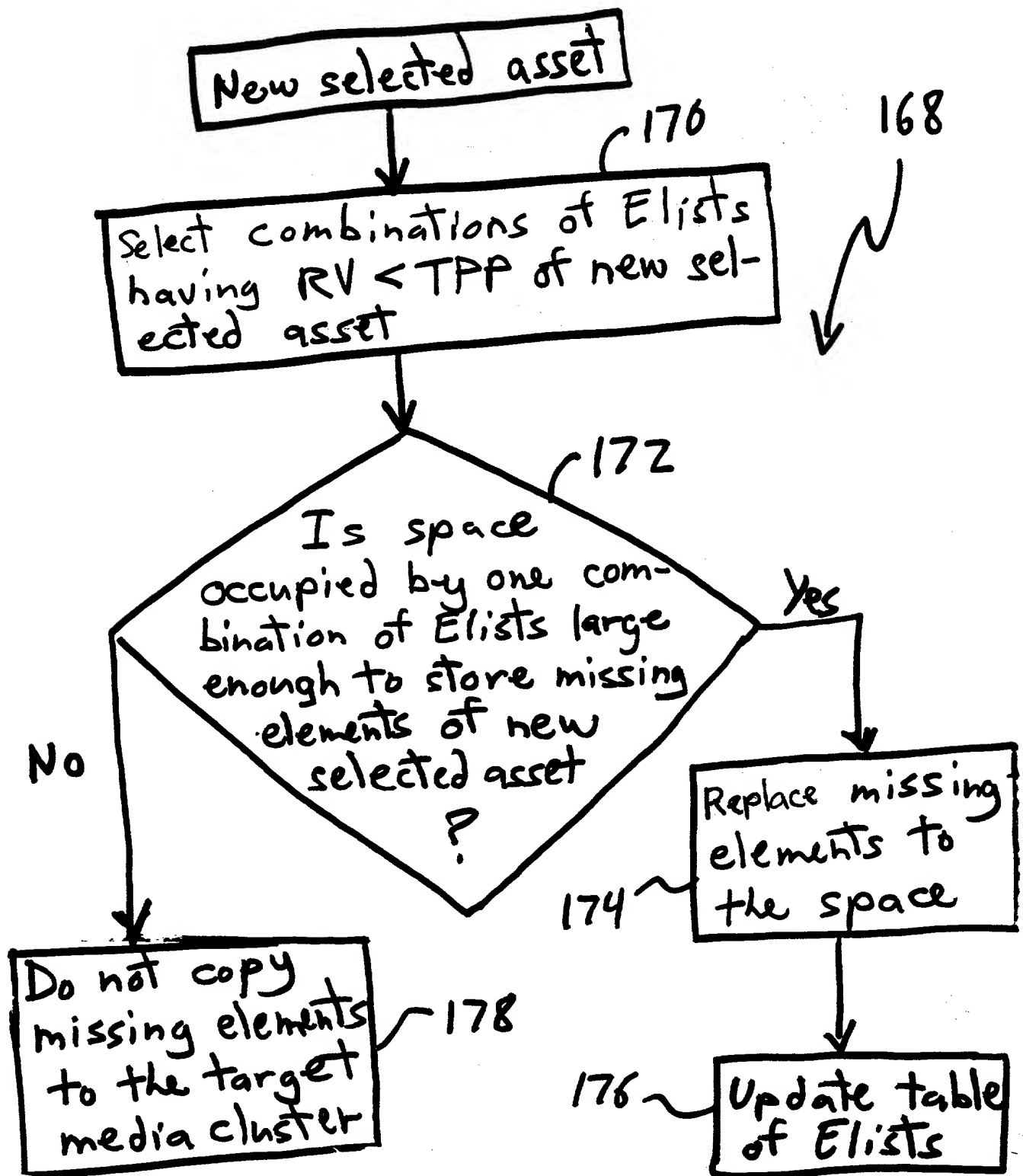


FIG. 10

Assign new asset to usage class ~182

Assign new asset GPP based in part on assignment to usage class ~184

Propagate replicas of new asset to new media clusters based on associated TPPs ~186

Update GPP of new asset in response to usage changes ~188

Update usage pattern of usage class in response to new usage data ~190

180 ↗

FIG. 11

Attorney's Docket No.: 07442-012001

**COMBINED DECLARATION AND POWER OF ATTORNEY**

As a below named inventor, I hereby declare that:

My residence, post office address and citizenship are as stated below next to my name,

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled CONTENT PROPAGATION IN INTERACTIVE TELEVISION, the specification of which:

- ☒ is attached hereto.  
☐ was filed on \_ as Application Serial No. \_ and was amended on \_\_\_\_\_.  
☐ was described and claimed in PCT International Application No. \_\_\_\_\_ filed on \_\_\_\_\_ and as amended under PCT Article 19 on \_\_\_\_\_.

I hereby state that I have reviewed and understand the contents of the above-identified specification, including the claims, as amended by any amendment referred to above.

I acknowledge the duty to disclose all information I know to be material to patentability in accordance with Title 37, Code of Federal Regulations, §1.56.

I hereby appoint the following attorneys and/or agents to prosecute this application and to transact all business in the Patent and Trademark Office connected therewith:

Gary A. Walpert, Reg. No. 26,098

Address all telephone calls to GARY A. WALPERT at telephone number (617) 542-5070.

Address all correspondence to GARY A. WALPERT at:

FISH & RICHARDSON P.C.  
225 Franklin Street  
Boston, MA 02110-2804

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patents issued thereon.

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Inventor's Signature: Mark Sanders

Date: 4/12/00

Residence Address: Carlisle, MA 01741

Citizenship: U.S.

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DRAWINGS  
FOR  
APPLICATION  
FOR  
UNITED STATES LETTERS PATENT

TITLE: CONTENT PROPAGATION IN INTERACTIVE  
TELEVISION  
APPLICANT: MARK SANDERS  
FIGURES: 1 through 11

CERTIFICATE OF MAILING BY EXPRESS MAIL

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April 12, 2000

Date of Deposit

Signature

MARK CARVEN  
Typed or Printed Name of Person Signing Certificate